2010 Milwaukee County LiDAR

Data Collection Overview

This section describes the operational parameters of the LiDAR sensor set for collection of data. The nominal objective for LiDAR Data Capture is – 70cm postings.

A. Capture Parameters

1. Flight Altitude: 760m/2500ft (nominal)
2. Point Spacing: 0.7m
3. Pulse Repetition Freq.: 70kHz
4. Scan Angle (+/-): 15.8 degrees
5. Scan Frequency: 56Hz
6. Swath Width: 430m/1400ft nominal
7. Overlap: 30%
8. Vertical Accuracy: 9.2cm – bare earth; 20cm vegetation and hillside, RMSE 18.2cm NSSDA Vertical Accuracy (95% confidence) – bare earth
9. Horizontal Accuracy: 30cm; RMSE
10. Returns: Up to four per pulse
11. Intensity records: Recorded for each return
12. Projected Coordinate System:
    a. NAD1927 State Plane Wisconsin South FIPS 4803
    b. Geographic Coordinate System: GCS North American 1927
13. Filtering: Automated methods with manual review and clean up with the following minimum performance specifications:
    a. 95% of outliers removed
    b. 95% of vegetation removed
    c. 98% of buildings removed
14. Contour Interval Meets or exceeds FEMA requirements to generate contours at a 1' interval independently verified.

B. LiDAR Data

1. Tiled* LAS files including Return Number and Intensity attribute for each return, duplicate points and 95% of outliers removed
2. Ground points classified via automated methods with manual review and clean up
    a. 95% of vegetation features removed
    b. 98% of buildings removed
3. Buildings and vegetation not classified separately
4. Data extends approximately 100' beyond the specified project area

5. Raw GPS/INS data and laser range files with supporting information

6. FGDC compliant metadata

7. Estimated Data Sizes (at 0.7m point spacing): approx. 20-25GB per 100 square miles

C. Additional Datasets

1. **Bare Earth ASCII:** points classified as ground (i.e. class 2) were exported to XYZI ASCII text format. One output file per LAS tile.

2. **Ground classified points:** in ASCII XYZI format tiled in same schema as base deliverable data files.

3. **First return LAS dataset:** a copy of the original dataset containing all first return points in LAS and ASCII XYZI format. Two output files are created per input LAS tile.

4. **First return points:** in LAS format tiled in same schema as base deliverable data files.

5. **First return points:** in ASCII XYZI format tiled in same schema as base delivered data files.

LiDAR Derivative Products

Derived Products Overview:

This specification addresses the standards for development of derived terrain products from classified LiDAR data. All activities and deliverables outlined in this document are in conformance with the USGS Base LiDAR Specification for USGS ARRA Projects, October 1, 2009 (USGS Specification) unless otherwise specified.

A. Derivative Products

1. **DEM (Bare Earth)**
2. **ESRI Terrain:** the Bare Earth classified data contained in the LAS files has been converted to ESRI Terrain data as a fundamental step toward deriving subsequent bare earth terrain products.
3. **Digital Elevation Models (DEMs):** the standard DEM deliverable has a 10-foot grid cell size. A Hillshade from the DEM has been included for visualization and cartographic mapping purposes.
4. **Collection-wide point data format:** (bare earth only) in ESRI multi-point format
5. **Terrain Data Model** (bare earth) in ArcGIS TERRAIN format
6. **Digital Elevation Model** (bare earth) in ArcGIS GRID format
7. **Hillshade** of the Bare earth DEM in ArcGIS format
8. **1-ft and 2-ft Contours:** Contours were created from smoothed data or not-smoothed data resulting in vector (line) data in ESRI Polyline Feature Class format. The output tiling scheme corresponds to 10,000 ft by 10,000 ft tiles. Tiled vector data is seamless and free of edge effects. Elevation attributes were established to each contour line and identify 10, 20, and 50 ft. index contours.

B. Breaklines

1. Standard Hydrographic Breaklines – included with DEM Breaklines are linear features that describe a change in the smoothness or continuity of a surface. As part of the baseline effort to create a DEM, limited 3D breaklines for water feature boundaries and wide rivers were developed, and incorporated into the ESRI Terrain data. Hydrographic breaklines were delineated using the LiDAR data with elevation values assigned from the LiDAR data, using best available aerial photography as reference.
2. Water bodies were defined as being larger than 5m across, or greater than one (1) acre. Breaklines delineating the edge of water were created for all such water

bodies. Breaklines have not been required for streams less than 5m across, also referred to in NHD as "single line streams".

3. The standard for water bodies in the USGS Specification is 100ft and two (2) acres respectively. "Hydro-flattening," as defined in the USGS Specification, was completed at a minimum on all water bodies meeting the USGS definition and is expected to meet or exceed the requirements for "Hydro-flattening" in the USGS Specification.

4. For flat and level water bodies (ponds, lakes), a single elevation value has been assigned to the entire polygon and/or to every bank vertex. The entire water surface edge is at or just below the immediately surrounding terrain. For streams and rivers, breaklines indicating flat and level bank-to-bank conditions (perpendicular to the apparent flow centerline) were created, with the gradient along the bank following the immediately surrounding terrain. Monotonicity has been enforced on breaklines meeting the USGS Specification. Stream and river breaklines delineating the edge of water stop at road crossings (i.e., culvert locations).

5. Bare earth LiDAR points that are within the design Nominal Point Spacing (NPS) of a breakline were re-classified as "Ignored Ground." The design NPS of a LiDAR collection is typically between 1 and 2 meters, but may be greater or less depending on the collection specifications of this project.

6. Additional Hydrographic and Slope Breaklines: Detailed hydrographic vector data has been generated from available digital imagery, elevation and vector GIS data. The reference data was to the NHD, along with the 2005 Milwaukee County hydrologic centerline dataset. The primary method for developing these data has been to map the location of the breaklines from the LiDAR data directly using best available aerial photography as a reference for extraction of surface features. To the extent that the location or the elevation of features cannot be adequately resolved, stereo-photogrammetric methods may be used. Additional hydrographic breaklines were developed as follows:

a. Stream Centerlines: For small streams <5m identifiable from the LiDAR data and/or the Orthophotography. The reference data for these channels included the 2005 Milwaukee County hydrologic dataset.

b. Edge of Water: For streams with identifiable water >5m across Note: the edge of the water is NOT synonymous with the edge of the stream channel depending on seasonal flow conditions in the stream.

c. Edge of Channel: For channels >5m across independent of the existence of visible water. Note: the edge of the channel is synonymous with the bottom of the stream bank.

d. Top of Bank: For all banks with clearly definable morphology 2 meters higher than the Edge of Channel. As such, it is possible for a stream segment to have anywhere from one to six unique breaklines representing the morphology of the stream. All stream centerlines and edge of water lines were tested for monotonicity (continuous downward slope).

e. The level and width of water within a stream channel may vary considerably throughout the year and can significantly impact breakline vector placement as well as point classification. It should be expected that vectors delineating water may differ from vectors indicating the top and/or bottom of the stream bank. Because of temporal variations in hydrologic conditions and water levels, it is expected that the shoreline edges associated with mean-water, low flow or other hydrologic recurrence interval may vary from those mapped by this effort. In addition, Stream Centerlines were derived for small streams only, and do not propagate through all water bodies as part of a linear hydrologic network.

f. In addition to delineating stream morphology, breaklines that delineate sharp breaks in slope on key terrain may affect the accuracy or representation of the derived surface, and the quality of resulting contours. Slope breaklines were developed across the project area in addition to those described for streams above. Surface roughness and slope change analysis were used to indicate places where breaklines are warranted, so that breaklines are extracted in places where real breaks exist in the smoothness of the terrain. Key terrain includes natural features such as ridges, valleys, bluffs, cliffs, and the tops of stream banks not otherwise included with hydrographic breaklines. Key terrain also includes manmade features such as dams, retaining walls or road cut structures or embankments that affect the slope of

the overall ground surface but might not otherwise be included with transportation breaklines.

7. **Transportation** (ESRI Polyline Feature Class format)**:** Transportation network related breaklines were generated as identified from best available imagery, elevation and vector GIS data. This includes breaklines representing the crown of the road (road centerline), the edge of the roadway (outer edge of the shoulder), and the centerline of any significant roadside ditches. Hence a typical two-lane roadway results in anywhere from 3 to 5 breaklines depending on the existence of drainage ditches along the side of the road. More complex roads and road interchanges may have warranted additional breaklines as necessary.

C. **Void Area Mapping** (ESRI Polygon Feature Class format): There has been a range of void areas on the bare earth data as a result of non-ground feature removal or absorption by water. Void area polygons were derived from the Bare Earth point data. This ancillary deliverable is particularly useful for Milwaukee County to have as a legacy of the collection to better understand and articulate the limitations and assumptions (i.e., interpolation) that are inherent in the derived data products. In accordance with both FEMA guidelines and the USGS Specifications, voids areas were mapped as follows:

1. Bare Earth Data ≤ 10m GRID (100m2)
2. First Return Data ≤ 8m GRID (64m2)
3. FEMA guidelines indicate that void areas greater than one (1) acre occurring in the floodplains may require additional ground survey, independent of the overall collection statistics. As such, land cover for Bare Earth void polygons larger than one acre were identified.

D. **Slope Data** (ArcGIS GRID format)**:** Percent rise and degree slope GRIDs from the DEM data were derived. The extent is the same as the source DEM with values for slope.

E. **Intensity Data** (Tiled in ArcGIS Grid format with ESRI raster catalog of all tiles): Intensity grids were developed from the data contained in the LAS files, with interpolation across voids. This data is particularly useful for Milwaukee County to use in urban planning and hydrologic applications such as evaluating land cover types, impervious surface areas and changes in the landscape. The data is tiled to the original LiDAR tiles, in ESRI GRID format with a grid cell size corresponding to the average post spacing of the all points LiDAR data. A raster catalog of all the tiles is also included.

F. **DSM (Reflective Surface)**, ArcGIS GRID format with 10-foot grid cell size:

Data contained in the LAS files has been converted to a raster based Digital Surface Model (DSM) representing a "first surface" detected by the sensor. This first surface is represented by both bare ground in open terrain, as well as the tops of trees and buildings in areas with significant non-ground features. The elevation value of each cell in the raster dataset represents the highest elevation value of points that fall within that cell. This surface model does not include the development or use of additional breaklines beyond that which are included with the bare earth data. Included with each DSM is a Hillshade for visualization and cartographic purposes.

G. **"Normalized" DSM (nDSM)** ArcGIS GRID format with 10-foot grid cell size:

An nDSM has been generated where the elevation value of each cell represents the height above ground of the highest point within that cell. For each surface model, cells with no points were interpolated based on the averaged values of nearby cells (nearest neighbor).